Abstract

A numerical study of 'Transpiration Cooling' by incorporating 'Binary Diffusion' has been conducted by solving two dimensional full Navier-Stokes equations The study is performed for hypersonic flows in the range of Mach number 6-8 Only laminar flows are considered The Reynolds number range for the present studies are fixed between 10^6 and 5×10^6 based on the data of a typical reentry trajectory Helium and carbondioxide gases used as transpirants are considered as chemically inert The freestream gas - Air is assumed to be a perfect gas

An appropriate computer code is developed for the purpose of obtaining flowfield solutions when a gas different from the freestream gas is injected at the surface of a flat plate The governing equations are cast in conservative form and descretised using finite volume network Time marching is carried out implicitly using Euler-Implicit scheme Line-Jacobi relaxation algorithm is used to solve the resulting set of equations The inviscid fluxes are treated using the Roe's flux difference scheme and the viscous fluxes are determined using auxiliary cell approach

The Navier-Stokes code so developed has been validated for variety of cases Flat plate body geometry is considered for the purpose of our study

In the present study " No net heat flow to the wall " condition has been used The wall temperature is determined based on this condition for a given freestream condition and a given gas Mass injection rate for the present study is estimated based on the no net heat to the wall condition and is not fixed arbitrarily

The effect of injection of helium and carbondioxide on various quantities such as pressure, skin friction and wall temperature are studied for a range of freestream conditions assuming both the gases to be perfect The mass injection rate was maintained constant along the length of the flat plate It is found that the effect of helium or carbondioxide on pressure is not significant when compared to its effect on skin friction and wall temperature It is found that the gas injection affects both the skin friction and the wall temperature in a similar way But it is found that helium has better capability to cool the surface compared to carbondioxide Correlations were developed for temperature reduction factor (ϕ) with blowing parameter (B) based on the solutions obtained It is found that ϕ cannot be correlated universally with B for different gases